

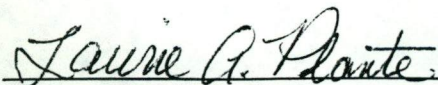
**FACILITY INVESTIGATION
PHASE I HYDROGEOLOGIC STUDY
TECHNICAL MEMORANDUM
DuPont Seaford Nylon Plant
Seaford, Delaware**

November 30, 1993

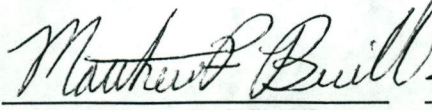
DERS Project No. 2755

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1.0 INTRODUCTION

The Task III Work Plan for Phase I of the Facility Investigation (FI) at the DuPont Seaford Nylon Plant was conditionally approved by the Environmental Protection Agency (EPA) Region III on May 21, 1993.

Section 2.2.1.1 and Section 3.4 of the work plan presented a scope of work for a facilitywide hydrogeologic investigation. The results of this investigation are presented in this technical memorandum. The groundwater sampling and related activities listed in the work plan will commence with the EPA's approval of the groundwater sampling locations proposed in Section 6.0 (and summarized in Table 4) of this memorandum. Completion of the Phase I FI will then proceed according to the revised FI schedule submitted to the EPA on October 26, 1993.

DuPont is still committed to implementing all activities discussed in Section 3.5 of the work plan. The discussions that follow, only propose modifications to the groundwater sampling activities.

DuPont feels that the phased approach of data gathering and subsequent evaluation, as evidenced by this memorandum, provides a technically sound and cost-effective method of implementing the Resource Conservation and Recovery Act (RCRA) Corrective Action process. DuPont appreciates the EPA's help and assistance in carrying out such an interactive approach.

1.1 PURPOSE AND SCOPE

This hydrogeologic investigation was undertaken as the first part of the Phase I FI to provide a better understanding of the hydrogeologic system on a facilitywide basis. The main objective of the investigation was to evaluate the groundwater flow system so that groundwater sample locations at solid waste management units (SWMUs) 1, 6, 9, 12, and 13 could be chosen based on current technically accurate groundwater flow patterns. The investigation also examined the effects of surface-water bodies, tidal

fluctuations, and plant production wells on these groundwater flow patterns.

The first part of the investigation included gathering information on existing site wells to assess their suitability for use in the evaluating the groundwater flow system. The well inventory results are presented in Section 2.0 of this memorandum.

New monitor wells (both single and in clusters) and piezometers were installed for this study to supplement the existing wells. These new groundwater level measuring points help provide more complete coverage across the site. The monitor well and piezometer installation program is described in Section 3.0 of this memorandum. During the course of well and piezometer installation, new geologic information was obtained. This information, along with revised geologic cross sections, will be presented in the Phase I RCRA FI report.

The tidal influence on the groundwater/surface-water relationship was examined. The results of the tidal influence investigation are presented in Section 4.0 of this memorandum.

Groundwater flow patterns across the site and their interrelationship with the surface water are presented in Section 5.0 of this memorandum. Based on this information, flow directions at each individual SWMU are discussed, and proposed well sampling locations are provided in Section 6.0 of this memorandum.

2.0 WELL INVENTORY

A records search was conducted during the month of July 1993 as part of the FI Phase I well inventory task to locate geologic boring logs and as-built well construction data. In addition to project files and plant records, data sources included CH2M Hill files and Delaware Geological Survey (DGS) well records. A computer records search was also performed by the Delaware Department of Natural Resources and Environmental Control's (DNREC's) Water Supply Branch; however, the search yielded no unique information, since records are incomplete prior to 1985. Well logs obtained as a result of the records search are provided in Appendix A.

Well records were reviewed for useful construction specifications or stratigraphic data that might fill data gaps in the existing well inventory, which was presented as Table 2-2 of the RFI Task I report entitled *Description of Current Conditions, DuPont Seaford Facility* (Paul C. Rizzo Associates 1993). This inventory was updated to include information regarding status (e.g., usable, abandoned), material of construction (e.g., PVC, carbon steel), and a list of geologic and construction logs located. The updated inventory is included as Table 1 of this memorandum.

A field verification search was conducted during July and August 1993 to locate and visually inspect wells listed in the existing well inventory. Information recorded at each well included: accessibility, lock type and number (if present), material of construction, apparent condition (e.g., usable, rusted, bent, abandoned), casing stick-up height, headspace photoionization detector (PID) measurements, depth to water, and total depth. Some wells listed in the inventory were not located, and this is noted in the updated inventory table. Results of the field verification were used to prepare a list of potentially usable wells for water-level monitoring and sampling. (See Exhibit 1 of Appendix A for these well logs, except for the production well logs which are in Exhibit 3.) Old locks were subsequently removed from the locked wells and replaced with keyed-alike

locks (identical to those on internal plant gates) prepared by the plant locksmith.

A sitewide well survey was conducted by McCann, Incorporated during the month of September 1993, after the new wells were drilled and installed. A total of 68 site wells were horizontally and vertically located based on existing plant benchmarks. Tabulated horizontal (southward and westward) locations were provided with respect to the established plant grid system. Historic records indicate that the plant grid system origin is located at latitude 38 degrees, 38 minutes 1 second north, and longitude 75 degrees, 37 minutes 11 seconds west. Top-of-casing elevations (outer and inner casings) were vertically located with respect to the established plant datum. [McCann, Inc., determined that the plant datum is 0.28 feet above National Geodetic Vertical Datum (NGVD)]. Measured casing stick-up heights were used to calculate approximate ground-surface elevations at each well.

3.0 WELL INSTALLATION

Drilling and well installation activities were conducted at the Seaford plant between July 29 and September 13, 1993. A total of six shallow monitor wells, six deep monitor wells, one piezometer and three still wells (surface-water gauges) were installed during this period as part of the RFI Phase I Hydrogeologic Study at the Seaford plant. The new wells were located throughout the eastern portion of the facility (see Figure 1) based on the placement rationale defined in Table 2-1 of the *RFI Task III Facility Investigation* (Paul C. Rizzo Associates—revision No. 2 to the work plan—May 1993).

3.1 DRILLING METHODS AND CONDITIONS ENCOUNTERED

A single CME-75 drilling rig, capable of conversion between hollow-stem auger (HSA) and mud-rotary drilling, was brought on-site by A. C. Schultes, Incorporated, on July 29, 1993, for installation of both shallow and deep wells. Shallow wells were drilled by HSA methods. A steel knock-out plate was employed at two locations (12MW-14S and L-7) where soil samples were not necessary because stratigraphic information was available from an adjacent deep boring. For deep wells, it was necessary to use mud-rotary drilling methods because of the occurrence of running or flowing sands at depths exceeding approximately 25 feet throughout the facility. Continuous samples were collected for subsurface lithologic characterization at each well by driving a 2-inch split-spoon sampler through 24-inch intervals in advance of the lead auger.

Auger drilling, using 4 1/4-inch-inner-diameter hollow-stem augers was the preferred drilling method. DuPont made every effort to continue drilling by HSA methods until running sands interfered with sampling and well installation activities. Thus, various methods were employed to prevent sands from running up into the augers. Initial attempts to control running sands involved placing a head of potable water in the augers. When hydraulic forces overcame the weight of the water column, a denser mixture of drilling mud (Aquagel Gold Seal® bentonite) was placed inside of the

augers to prevent the sands from running in. The added weight of the mud allowed HSA drilling and sampling to continue to a greater depth than would otherwise have been possible. However, at depth, this method eventually failed to control the sands and mud-rotary methods were employed thereafter.

Prevailing conditions (low pH groundwater) made it difficult to maintain a drilling mud of sufficient thickness to prevent borehole collapse. Thus, mud-rotary borings were overdrilled with 4 1/4-inch-inner-diameter hollow-stem augers. The augers served as a temporary casing to stabilize borehole walls. The method was extremely slow, but effective. On termination of drilling, drilling mud was displaced by flushing potable water through the augers until it ran clear. Because the overdrilling effectively removed the mudcake lining that forms on borehole walls during mud-rotary drilling, minimal mud thinning was required.

On August 27, 1993, DuPont obtained the EPA's permission to use straight mud-rotary drilling methods thereafter because of the demonstrated occurrence of running sands in deeper zones throughout the site. A second drilling rig (Failing model 1250) was brought on-site on August 31, 1993. Drilling progressed at an accelerated pace with the larger mud-rotary drilling rig.

To obtain continuous soil samples with the larger mud-rotary drilling rig, a 2-inch-diameter split-spoon sampler, suspended by a steel cable and drilling jars, was driven through the center of the drill bit by repeatedly raising and then dropping the spoon over a 30-inch interval. This method proved to be effective in sample retrieval for lithologic logging purposes. The muds were thinned upon completion of drilling by flushing water through the rods until return fluids were visibly clearer.

Discontinuous clay lenses separating the shallow (water table) and deep saturated zones of the Colombia Formation were encountered at some drilling locations in accordance with the conceptual geologic framework

depicted by previously presented cross sections (see Figures 2-3 through 2-8 of the Task I report). In the southern portion of the site, clay was encountered from 18 to 24 feet below grade at well cluster 12MW-13S/D, confirming the presence of a shallow confining unit in the vicinity of SWMU 13. However, the absence of a shallow confining unit at well cluster 12MW-14S/D indicates that the unit probably pinches out beneath SWMU 13.

The existence of a shallow confining unit in close proximity to the Nanticoke River was confirmed at well cluster MW-10S/D and at well 6MW-1. However, the unit was not encountered at piezometer PZ-1, indicating that it likely pinches out to the east.

In the northern portion of the site in the vicinity of SWMU 1 no distinct shallow confining unit separating the water table zone from the deep saturated zone exists at well cluster L-7/L-7D or at well L-2D, both of which are located to the west of SWMU 1. However, an intermediate-depth clay unit was encountered at L-7D (58 feet below grade). An intermediate-depth clay unit was likewise encountered at well cluster L-6/L-6D to the east (33.5 feet below grade).

At 12MW-14S/D, fill materials containing bulk fibrous nylon and black, oily, creosote-treated wood were encountered down to a depth of approximately 7 to 8 feet below grade. Apparently, this well cluster was inadvertently sited within the bounds of SWMU 13 in an attempt to locate the well outside of the perimeter of nearby SWMU 12. Spike headspace readings at the borehole, measured by an organic vapor analyzer (OVA), were as high as 450 pounds parts per million (ppm), but the vapors quickly dissipated and no vapors were detected in the breathing space. Buried wastes were not encountered at other drilling locations.

3.2 WELL DEPTH RATIONALE

Shallow wells were advanced to a depth of 20 to 25 feet below grade or to the top of the uppermost shallow confining unit where present within

25 feet of the ground surface. Deep borings were advanced to the top of the characteristically bluish gray clayey silt confining unit that marks the base of the Columbia Formation. However, an exception was made in the vicinity of SWMU 1, where an intermediate-depth clayey silt confining unit was encountered at depths ranging from 33.5 feet below grade at L-6D (in the low-lying area east of the SWMU) to 58 feet below grade at L-7D (approximately 400 feet west of the SWMU). At these locations, deep borings were terminated at the top of this intermediate-depth confining unit.

3.3 WELL CONSTRUCTION SPECIFICATIONS

Monitor wells were constructed of threaded, flush-joint, 2-inch-inner-diameter, schedule 40 polyvinyl chloride (PVC) casing and riser pipe, with 0.020-inch, factory-slotted, schedule 40 PVC screen and end caps. Based on the driller's experience installing wells elsewhere within the Columbia Formation, 0.020-inch, factory-slotted PVC screen was used rather than the 0.010-inch slot-size specified in the work plan. Thus, except at well L-7D where a 10-foot section of screen was used, all screens consisted of 5 feet of 0.020-inch, factory-slotted PVC. At each location, number 1 Morie Gravel was extended approximately 2 feet above the top of the screened interval as specified in the work plan. The gravel pack was topped with a bentonite pellet seal and tremie-placed cement/bentonite grout, as per work plan specifications. Locking 6-inch diameter protective steel surface casings were grouted in place at each location, and wells were completed with a concrete pad and protective bollards. Table 2 contains a summary of as-built construction details for new monitor wells. Individual boring logs with well construction specifications are included in Appendix A (Exhibit 1).

New monitor wells were developed following installation and prior to commencement of continuous tidal monitoring that started on September 16, 1993. Shallow wells (with the exception of 12MW-13S and L-6) were developed using a centrifugal jet pump fitted with polyethylene tubing and a foot-valve. Because of low well volumes and slow rates of recharge at wells 12MW-13S and L-6, it was necessary to use hand-bailing

development methods at these wells. Deep wells (with the exception of 12MW-13D and L-6D) were developed by the air-lift method, which involves jetting compressed air through an airline placed inside of a temporary polyethylene eductor pipe inserted into the well to force water up and out of the well (through a tee in the pipe at the wellhead). Wells 12MW-13D and L-6D were developed using a centrifugal pump fitted with a foot-valve. Development continued, with periodic physical agitation, until purge water was noticeably clearer. All purge water, temporarily contained at the wellhead, was eventually transferred to one of two wastewater tankers on-site for characterization and disposal.

3.4 STILL WELL INSTALLATION

Still wells, consisting of 4-inch-diameter, factory-slotted, schedule 40 PVC, were installed at three surface-water gauging locations on July 29, 1993 (see Figure 1). One still well (SG-1) was attached to the plant intake structure on the Nanticoke River. A second still well (SG-2) was secured to a wooden frame at the edge of the tidal portion of the drainage ditch that flows across the site. A third still well (SG-3) was temporarily attached to a Woodland Road bridge, where it crosses Chapel Branch, using removable brackets, since permission was not granted to permanently attach a well to this publicly owned bridge. Still wells were horizontally and vertically located during the sitewide well survey during the month of September.

4.0 TIDAL INFLUENCE STUDY

4.1 TIDAL MONITORING

Groundwater levels in selected site wells were monitored continuously for one week, beginning September 16, 1993, and ending September 23, 1993, to determine the extent of the Nanticoke River tidal influence in shallow and deep monitor wells at the Seaford plant. In accordance with the approved work plan, pressure transducers were placed in the 15 new and existing site wells and in two still well stream gauges (SG-1, located at the plant intake structure on the Nanticoke River, and SG-2, located in the tidal portion of the drainage ditch that flows across the plant). An additional transducer was set up at the Nanticoke River data logger to monitor barometric pressure changes during the tidal monitoring event. Raw, continuous monitoring data is presented in Appendix B, and water-level hydrographs are included in Appendix C.

Six Hermit 2000 data loggers were programmed to record measurements at 20-minute intervals for 7 days, beginning at 10:00 A.M. on September 16, 1993. However, a damaged pressure transducer cable at well L-6 had to be replaced during the first day of continuous monitoring, resulting in a delayed restart for wells L-6 and L-6D (1,570 and 380 minutes, respectively).

During the continuous monitoring period, manual water-level measurements were collected daily from active production wells and selected monitor wells specified in the work plan. Measurements were not taken from two of the shallow monitor wells specified in the work plan, however, since one of the wells (OW-2) could not be located and another was damaged (MW-22C).

Transducers were checked daily for instrument drift during the continuous monitoring period by comparing data logger readings with manual measurements at each well. Corrections were made as needed, but no major malfunctions were noted during the monitoring period. However, when data was downloaded on September 23, 1993, a system malfunction

was readily apparent at the data logger set up to continuously monitor Nanticoke River levels and barometric pressure changes. Although the pressure transducers at this location appeared to be functioning normally during the test (based on daily instrument drift checks), the data logger failed to record any river elevations or barometric pressure readings after the first 7 hours and 40 minutes of the test. According to the instrument manufacturer, In-Situ, Incorporated, the internal central processing unit of Hermit data loggers can occasionally shut down (particularly in older instruments) and the situation cannot be detected until the data is downloaded.

4.2 DATA INTERPRETATION

Continuous water-level monitoring data for the Nanticoke River, measured at still well SG-1, captured an initial low tide but missed the following high tide when the Hermit data logger malfunctioned after the initial 7 hours and 40 minutes of the tidal monitoring period. Continuous tide elevation data is graphically depicted in Figure C-1 (see Appendix C). All measurements are referenced to the plant datum elevation based on results of the sitewide survey.

Predicted tide data for the duration of the monitoring period was obtained from *Reed's Nautical Almanac: North American East Coast 1993*. Predicted tides, in feet NGVD, are provided for Hampton Roads, Virginia, together with a correction factor for computing predicted tides at the Sharptown, Maryland, station located on the Nanticoke River approximately 8 to 10 miles downstream from the site. The initial low tide recorded at the site occurred approximately 26 minutes after the scheduled low tide at Sharptown, Maryland, and this 26-minute delay is believed to represent the tidal time lag between Sharptown, Maryland, and Seaford, Delaware. Thus, predicted tides for Sharptown, Maryland, were corrected for the 26-minute time lag and plotted for the duration of the tidal monitoring period (see Figure C-2 of Appendix C).

A close correlation between actual and predicted tide data can be seen by overlaying continuous Nanticoke River monitoring data (see Figure C-1 of Appendix C) and predicted tide data (see Figure C-2 of Appendix C). Based on the observed alignment of actual and predicted tide data, the plant datum appears to be approximately 1-foot above NGVD. The observed correlation between actual and predicted tide data justifies the use of predicted tide data in the tidal study data analysis.

The pressure transducers used for the test (In-Situ, model PDX-260) are vented to the atmosphere so that barometric pressure effects are automatically corrected. Therefore, a correction for barometric efficiency is unnecessary. However, because of the data logger malfunction, the pressure transducer that was set up to continually record barometric pressure produced no results after the first 7 hours and 40 minutes. Although the backup barometric pressure data was lost, no corrections were needed for atmospheric pressure changes since the transducers factor out these effects automatically.

Hydrographs that represent continuous water-level measurements at the drainage ditch still well (SG-2) and the individual monitor wells are presented in Appendix C. For cluster wells, continuous shallow and deep zone monitoring data is depicted on a single hydrograph in order to graphically represent vertical gradients. A running, 72-hour filtered mean was calculated and plotted for each well.

Tidal time lag was determined graphically based on continuous monitoring data. The time at which low tide was recorded at the Nanticoke River still well was compared to the time at which the low tide was reflected in tidally influenced wells. Table D-1 (see Appendix D) summarizes time lags and tidal efficiencies calculated for continuously monitored wells. The calculated time lag in the shallow water table zone and deep saturated zone were contoured for sitewide interpretation (see Figures D-1 and D-2 of Appendix D). Table D-2 presents approximate time lags for all of the usable

monitor wells, determined by graphical analysis. The time lag is useful in determining the optimum water-level monitoring schedule (see Appendix D).

4.3 RESULTS OF ANALYSIS

If a 26-minute tidal time lag is applied, predicted tides appear to closely match observed tide data recorded during the initial 7.7 hours of the test. Based on the observed correlation, plant datum appears to be approximately 1 foot above NGVD. Tidal effects in the shallow and deep saturated zones are discussed below.

4.3.1 Shallow (Water-table) Aquifer

The following items summarize the tidal effects for the shallow wells:

- Nanticoke River tides have minimal impact on water levels in the shallow site wells. Those shallow wells located in close proximity to the Nanticoke River (e.g., MW-10S, located approximately 300 feet from the river) or the tidal portion of the drainage ditch (e.g., MW-3S and 12MW-14S, located approximately 95 and 340 feet from the tidal portion of the ditch, respectively) show tidally induced water-level fluctuations of up to 0.25 feet. Because of the damping effect, however, shallow wells located beyond a distance of approximately 500 feet from the tidally influenced surface-water bodies show no tidal influence.
- No tidal influence was observed in the shallow wells located in the northern portion of the site. However, the hydrograph for shallow well L-6 shows water-level fluctuations that cannot be attributed to cyclic tidal effects. Water levels at this well, which extends to a depth of only 5 feet below grade and is located adjacent to a marshy area, appear to be strongly influenced by direct precipitation infiltration. Water level rises of up to a foot on September 18, 1993, and September 21, 1993, correspond with precipitation events on these days.

4.3.2 Deep Saturated Zone

The following items summarize the tidal effects for the deep wells:

- Daily water-level fluctuations observed in the majority of the continuously monitored deep wells indicate significant tidal influence for the deep saturated zone, with tidal influence decreasing with

distance from the Nanticoke River. The maximum observed daily fluctuation (1.3 feet) was recorded at well MW-10D, located within 500 feet of the river. Minimum daily fluctuations (0.25 feet) were seen in well 12MW-13D, the intended background well, which is located more than 2,500 feet from the river.

- Despite significant tidal influence in the deep saturated zone, mean flow directions appear to be off site toward the Nanticoke River.

Tidal effects in the vicinity of SWMU 1 were absent or minor, with maximum fluctuations of 0.2 feet at well L-6D (located east of the SWMU). Well L-2D, located just west of the SWMU, showed minimal tidal influence, with fluctuations of only 0.06 feet. Well L-7D appears to have no tidal influence.

An arithmetic mean was run on the predicted tide data for use in determining mean flow directions (see Figure C-14 of Appendix C). Comparison of arithmetic mean levels (predicted) with 72-hour running mean data indicate that the mean gradient is toward the river in both the shallow and deep saturated zones, despite slight gradient reversals at high tide.

An optimized water-level monitoring schedule is presented in Appendix D.

12MW-14S will also be proposed as an additional location for Appendix IX. This newly installed well also turns out to be screened under the middle of the northern portion of the SWMU (see Figures 2 and 3). The same rationale that makes MW-8S a good sampling location also applies to the location of 12MW-14S. Therefore, in addition to MW-8S which is already proposed for sampling, 12MW-14S will be added.

Well locations 3S/3D, 4S, 5S/5D, and 9S will be considered for future sampling, contingent upon the results of the Phase I sampling results and whether a release has been detected in wells MW-8S and 12MW-14S.

flow radially from this area. A portion of the groundwater immediately beneath SWMU 12 moves in the direction of the Nanticoke River, either due east (past 12MW-14S/D) or in a southeasterly direction (past MW-8S). Some smaller component of flow is southwesterly towards Chapel Branch Creek. The pumping of plant production well PW-11 is strongly influencing groundwater flow within its immediate vicinity. The net effect of PW-11's pumping is to increase the velocity of any groundwater already flowing between MW-10A and Chapel Branch.

The following well locations are proposed for sampling because they are best situated to assess whether a release from SWMU 12 has occurred: MW-8A, MW-7, MW-5, MW-4, and MW-1A. The following wells are also proposed for sampling because they are best situated to assess whether a potential release may have migrated away from the SWMU: 12MW-14S, 12MW-13S/13D and MW-2. Because of their close proximity to the wells just listed, MW-3, MW-11, MW-10A, and MW-6 are not proposed for sampling at this time.

With regard to assessing potential releases to groundwater from SWMU 9, MW-2 is considered the downgradient well and MW-4 the upgradient monitoring point. For this reason, MW-2 will receive analysis for the full Appendix IX parameter list.

The remaining monitor well samples will be analyzed for the volatile organic, semivolatile organic, and inorganic compounds found on the Appendix IX list.

6.4 SWMU 13

Groundwater beneath SWMU 13 appears to flow toward the east and southeast in the direction of the Nanticoke River. The work plan proposes to sample MW-8S for full Appendix IX parameters, "because the location is under the western end of the SWMU and should characterize any and all contaminants that could possibly be released to groundwater from the SWMU 13." In addition to sampling MW-8S for Appendix IX parameters,

An upward hydraulic gradient appears to exist, as indicated by the water levels in well clusters L-2/2D and L-6/6D. This is not seen in L-7/7D, probably because the production well is screened in the same zone as L-7D and "artificially" lowers its water level more so than L-7. Although the existence of an upward hydraulic gradient beneath the SWMU seems probable, all of the deep wells (L-2D, 6D, and 7D) in the area will be sampled. This is because an upward groundwater flow direction does not preclude the downward migration of dense nonaqueous phase liquids (DNAPLS) and certain chlorinated compounds with specific gravities greater than water.

The recommend sampling and analysis do not differ from the original sampling, and analysis in the Task III work plan.

6.2 SWMU 6

Groundwater in the area appears to flow naturally toward the Nanticoke River. The drainage ditch receives millions of gallons a day of cooling water, primarily from the National Pollutant Discharge Elimination System (NPDES) outfall 002. Some of the water appears to infiltrate from the ditch to the water table, artificially recharging the groundwater and creating a mounding effect immediately under the ditch banks. The ditch recharge does not seem to have a significant effect on the overall groundwater flow direction, which remains toward the river.

The majority of the solid waste in the SWMU was reportedly placed on the side of the ditch closest to the plant. Monitor well 6MW-1 is still in a good position to intercept any potential leachate migrating from the unit. Therefore, the well location and sample analysis previously proposed in the work plan is still appropriate.

6.3 SWMU 9 AND SWMU 12

The groundwater elevation measurements shown on Figures 2 and 3 indicate a mounding effect in the areas of SWMU 9 and 12. The water table is highest in the area of wells 10A, 11, and 6; groundwater appears to

6.0 RECOMMENDED GROUNDWATER SAMPLING LOCATIONS

This hydrogeologic investigation was undertaken as the first part of the Phase I FI to provide a better understanding of the hydrogeologic system on a facilitywide basis. The main objective of the investigation was to evaluate the groundwater flow system so groundwater sample locations at SWMUs 1, 6, 9, 12, and 13 could be chosen based on current technically accurate groundwater flow patterns.

Unless stated otherwise in one of the subsections that follow, DuPont will carry out all activities stated in Section 3.5 of the work plan.

6.1 SWMU 1

Groundwater in the immediate area of SWMU 1 flows is toward the Nanticoke River in both the deep and shallow parts of the surficial aquifer. However, well L-7D, which is located approximately 400 feet west of SWMU 1, appears to show some influence due to the pumping of plant production well PW-2A. A groundwater divide apparently exists somewhere in the vicinity of L-7/7D. Groundwater at L-3, L-2, and L-1 flows toward the Nanticoke River, and groundwater in the area of L-7D flows towards PW-2A. Regardless of the exact position of this divide, the eight sample locations (11 wells total) already proposed for sampling in the work plan should still be capable of assessing whether contaminants have migrated via groundwater transport away from the SWMU. The eight locations (i.e., L-1 through L-7 and PW-8) will also provide an indication of which direction a potential plume could be migrating.

The work plan specifies that two samples (one shallow and one deep) should be analyzed for the Appendix IX list of compounds found in 40 CFR 264, and for formaldehyde. Based on the groundwater flow direction described above, wells L-6 and L-6D are the two downgradient wells that should receive complete analysis. The other nine wells receive the analyses as specified in the work plan.

under the ditch; this mounding effect is not significant in the context of changing groundwater flow directions on a scale that would effect the sampling proposed at SWMU 6.

A well-defined mounding effect exists at SWMU 12. This significantly influences the flow directions. The sampling strategy outlined in Section 6.3 accounts for this radial flow pattern.

As discussed in Section 5.0, the tides in the Nanticoke River do effect groundwater elevations in certain areas of the site. In general, the closer to the river and the deeper in the aquifer one measures, the more significant the tidal influence. The tides are not thought to be significant with regard to the groundwater sampling strategy since most of the SWMUs are beyond the influence of the tides. However, they must be accounted for when evaluating the useability of groundwater elevation data taken near the river to develop groundwater flow maps.

A full round of water-level measurements was collected from useable site monitor wells (as determined by the well inventory task) on September 16, 1993, following completion of well installation and development earlier in the month. The initial round of water-level measurements coincided with the first day of the tidal monitoring event. Shallow (water-table) and deep saturated zone flow directions for the month of September are graphically represented on Figures 2 and 4, respectively.

A second round of water-level measurements was collected the following month on October 18, 1993, to fulfill work plan requirements for two complete rounds of measurements for the hydrogeologic investigation. Figures 3 and 5 provide water-level measurements and flow directions for the shallow and deep saturated zones for the month of October. Water-level measurement data for September and October is presented in Table 3.

5.0 GROUNDWATER FLOW DIRECTION

Groundwater flow directions in both the deep and shallow portions of the saturated zone beneath the Seaford Nylon Plant can be influenced by the following three factors: surface-water bodies, tides, and groundwater withdrawal by the plant.

Regionally, groundwater in the Columbia Formation flows from topographically high areas west and north of Seaford toward the Nanticoke River, which is a major regional groundwater discharge zone. At some times of the year, as much as 80 percent of the Nanticoke River flow may be sustained by groundwater discharge (Sundstrom and Pickett 1970).

In an unstressed groundwater system, the groundwater across the site appears to discharge to either the Nanticoke River or to Chapel Branch Creek. One of the most noticeable stresses in the system is the plant production wells. Currently the plant withdraws over 530 million gallons per day from PW-2A, PW-9, PW-10 and PW-11. (PW-8 and PW-12 are presently inactive because of increasing iron concentrations.) The radius of influence at each well near the base of the Columbia Formation can be clearly seen in Figures 4 and 5.

From the perspective of changing a natural flow direction near any of the SWMUs, only PW-2A's pumping is significant. It appears to reverse the natural flow path of groundwater in the area of PW-8 (which would otherwise be toward SWMU 1 and the river). In the area of SWMU 12, the pumping of PW-11 only serves to increase the gradient (which is naturally toward Chapel Branch Creek) toward Chapel Branch Creek.

The drainage ditch artificially recharges the groundwater and receives millions of gallons of water per day from plant operations (e.g., non-contact cooling water). The majority of this water discharges to the Nanticoke River through channel flow. Based on a comparison of elevations, some water appears to be lost to groundwater. A relatively small mounding effect exists